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Three extraordinary new species of Psocoptera (Insecta) from Colombia, Malaysia and Thailand (Epipsocidae, Lachesillidae, Ectopsocidae)

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Three extraordinary new species of Psocoptera (Insecta) from Colombia, Malaysia and Thailand (Epipsocidae, Lachesillidae, Ectopsocidae). - The following species are described and illustrated: *Odontopsocus compactus* sp. n. (Colombia), *Lachesilla hirsuta* sp. n. (Thailand), *Ectopsocus venosus* sp. n. (East Malaysia: Sabah). Each of them is characterized by a morphological structure which is unusual within the genus concerned and, in the case of *Odontopsocus compactus*, unique within the order Psocoptera. The presence of a cup-like, unsegmented and heavily sclerotized abdominal carapace in this species is discussed in the light of its mode of life in humid moss and litter and is compared with similar convergent structures in other psocids.

Key-words: Psocoptera - Epipsocidae - Lachesillidae - Ectopsocidae - new species - Colombia - Malaysia - Thailand - litter dwellers.

INTRODUCTION

Some years ago, when sorting out samples of unidentified tropical Psocoptera in the collection of the Natural History Museum of Geneva (MHNG), I was particularly impressed by three species belonging to Epipsocidae, Lachesillidae and Ectopsocidae respectively, each showing a striking morphological character which is completely unusual for members of the family concerned: an apterous epipsocid female from Colombia with heavily sclerotized abdominal terga, fused to form a compact cup-like carapace; a lachesillid from Thailand with strongly pilose head and forewings; an ectopsocid from East Malaysia (Sabah) with atypical forewing venation (veins *rs* and *m* multi-branched).

My first reaction was to think that each of these species could represent an unknown genus. But further morphological study of the material showed that in each case general and genital characters correspond fairly well to a described genus of the family concerned. Therefore I hesitate to consider the extraordinary characters mentioned above as of generic value unless they have been observed in other species. The

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three new species are placed here in the genera *Odontopsocus* Badonnel, *Lachesilla* Westwood and *Ectopsocus* McLachlan respectively. Their description can be considered as a contribution to the knowledge of character range within the genera concerned and, in the case of *Odontopsocus*, it may illustrate a morphological adaptation to the hemiedaphic mode of life of this species in humid moss and litter.

The following abbreviations are used in the descriptions: BL = body length; A = antenna length; FW = forewing length; F = length of hind femur; T = length of hind tibia; t1, t2 = length of hind tarsomeres (from condyle to condyle); IO/D = shortest distance between compound eyes divided by antero-posterior diameter of compound eye, in dorsal view of head; f1, f2, ... = antennal flagellomeres; v1, v2, v3 = ventral, dorsal and external valvula of gonapophyses. For standard abbreviations concerning wing morphology, see Lienhard (1998).

TAXONOMIC TREATMENT

Odontopsocus compactus sp. n. Figs 1, 2

MATERIAL

Holotype ♀ (MHNG, slide no 7450). COLOMBIA: Dept. Magdalena: Northern Sierra Nevada de Santa Marta, near San Lorenzo, 2250 m, humid bamboo forest, in moss and litter, 22.VIII.1985, leg. H.-G. Müller.

Paratype ♀ (MHNG, in alcohol). Same locality as holotype, but 2200 m, in moss and litter on wayside, 18.-25.VIII.1985, leg. H.-G. Müller.

DIAGNOSIS

Female apterous, with fused and heavily scerotized abdominal terga forming a compact cup-like carapace.

DESCRIPTION (♀)

Coloration. Head and abdominal terga blackish brown, glossy; compound eyes black; antennae brown; maxillary palps, thorax, legs and terminalia dark brown; abdominal sterna whitish with some red-brown hypodermal pigment.

Morphology. Apterous. Habitus characteristic (figs 1g; 2a, b), due to the completely fused abdominal terga forming a heavily sclerotized cup-like carapace, which overlaps anteriorly the weakly developed thoracic terga, so that, in a contracted specimen, its anterior margin fits the posterior part of the normally rounded vertex. The glossy dorsal shield shows no trace of segmentation, it is completely glabrous but bears some very fine hyaline pores. Its prominent anterior margin is sharply delimited, bearing a membranous cuticula on its ventral side. The lateral margins of the shield are also sharply delimited, slightly prominent laterally and bearing the spiracles on their membranous ventral surface. The ventral side of the abdomen is entirely membranous, except the somewhat sclerotized subgenital plate.

Compound eyes relatively large (IO/D = 1.5), posteriorly protruding beyond vertex (figs 1g, 2a). Ocelli absent. Antennae relatively short, flagellomeres with some long setae, the longest of them somewhat exceeding the length of the corresponding flagellomere, f1 slightly curved, f5, f7 and f9 only about half as long as adjacent

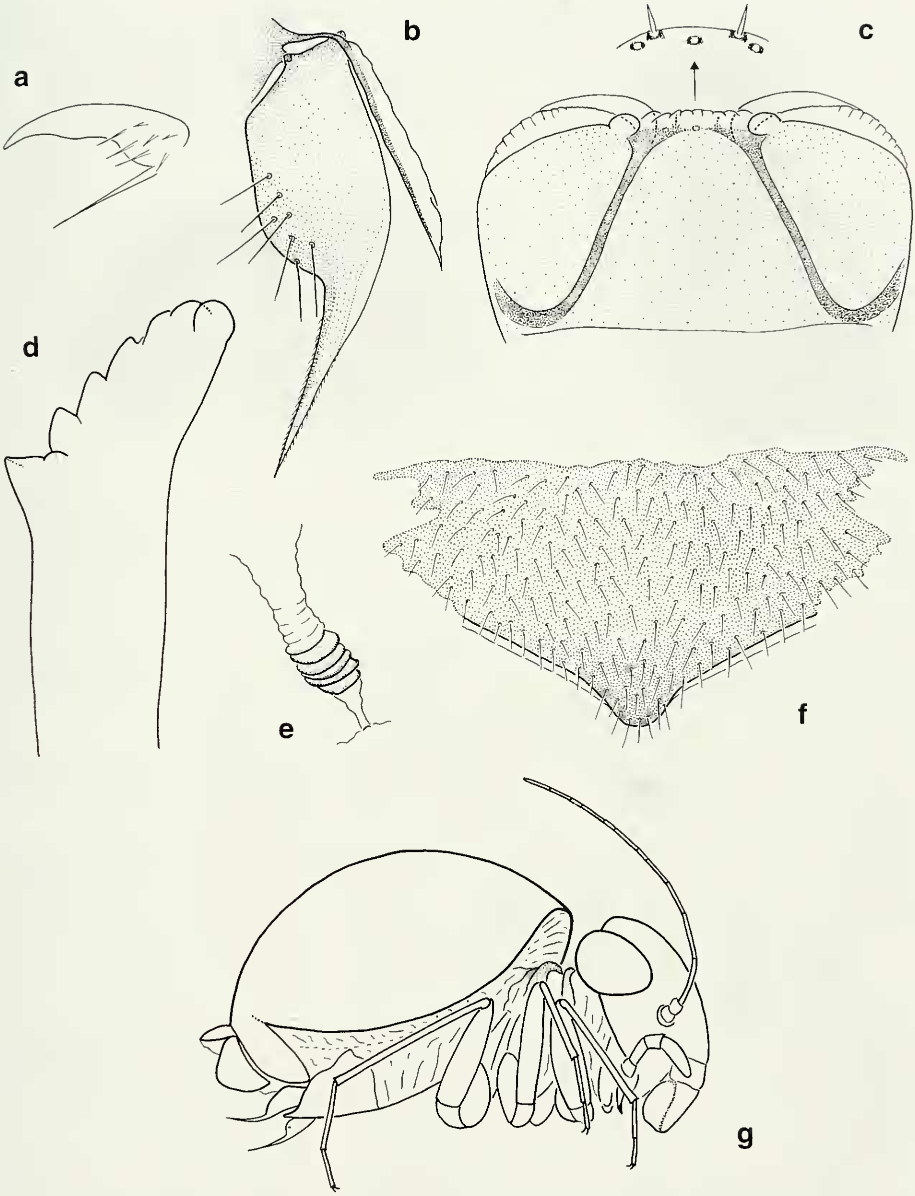

FIG. 1

Odontopsocus compactus sp. n., female: **a**, pretarsal claw; **b**, gonapophyses; **c**, labrum (pilosity not shown), with detail of marginal sensilla; **d**, lacinial tip; **e**, spermathecal duct; **f**, subgenital plate; **g**, habitus, lateral view (pilosity, pigmentation and sclerotization not shown).

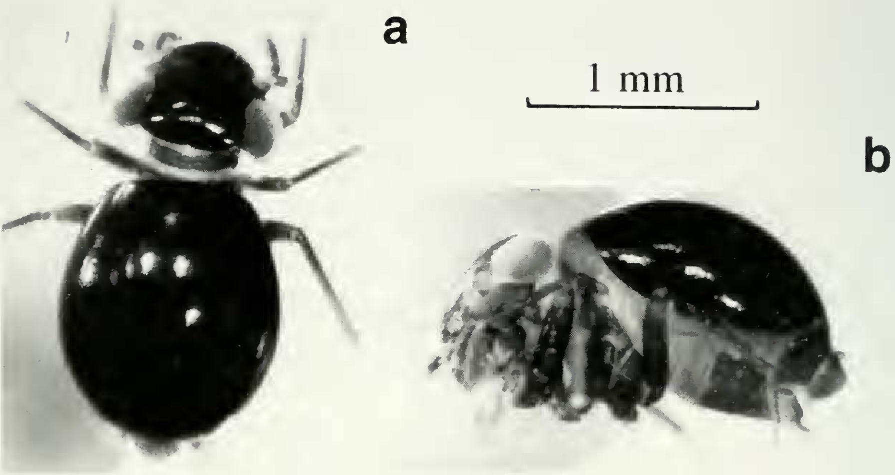

FIG. 2
Odontopsocus compactus sp. n., female, habitus: **a**, holotype, dorsal view; **b**, paratype, lateral view.

flagellomeres. Lacinial tip with long, relatively slender, denticulate outer cusp (fig. 1d). Labrum as in fig. 1c. No cones on femora. Pretarsal claws without preapical denticle (fig. 1a). Pearman's organ on hind coxa absent.

Clunium medially fused with abdominal carapace, laterally free (figs 1g, 2b). Epiproct and paraprocts free, simple, no trichobothria on paraprocts. Subgenital plate with a weakly developed rounded apical lobe (fig. 1f). Gonapophyses (fig. 1b): v1 present, joined by a sclerotic strip to clunium, v3 fused with v2, forming a slight swelling on its side, bearing some hairs, v2 terminating in a long acuminate process. Spermatheca membranous, its duct with some slightly sclerotized annulations (fig. 1e), spermapore without sclerotization.

Measurements (♀ holotype). BL = 1.8 mm; A = 1.2 mm; F = 470 µm; T = 630 µm; t1 = 240 µm; t2 = 160 µm.

Remark. The male of this species (predicted to be fully winged, as all known epipsocid males are) is not yet known, but the presence of sperm in the spermatheca of the dissected female gives evidence of the bisexuality of the species.

DISCUSSION

Based on female characters only, the generic placement is difficult. According to the revised diagnoses of the episocid genera (Mockford, 1998) the species is probably best placed in *Odontopsocus* Badonnel, due to the absence of the preapical denticle of pretarsal claws, the aptery of females and the long, relatively slender, denticulate outer cusp of lacinial tip. This genus is known from Venezuela, from where two species have been described: *O. orghidani* Badonnel, the type species (Badonnel, 1987) and *O. badonneli* Mockford (Mockford, 1996), both known in female sex only. Before defining a new genus for the Colombian species, based on the presence of the undoubtedly apomorphic abdominal carapace, I prefer to wait for the availability of more material, particularly males. The following observations on apterous females of two other psocid genera endorse this decision; some variation is observed concerning abdominal sclerotization between different species of the same genus.

In the family Epipsocidae, the presence of fused and heavily sclerotized abdominal terga in apterous females is known in one species of the Oriental genus *Hinduipsocus* Badonnel (cf. Badonnel, 1981: fig. 51), but in this species, *H. atratus* Badonnel, the abdominal terga do not form a capsule-like structure, overlapping thoracic terga, as it is present in the new species. In the other three known species of *Hinduipsocus* some abdominal segmentation is always visible and terga are more or less membranous, at least in the apical half of the abdomen; in *H. coleoptratus* New the abdominal terga 1 to 4 are heavily sclerotized, similar to *H. atratus*, while the other preclunial terga are membranous (cf. New, 1987: figs 1-3). Another example within the suborder Psocomorpha, for the presence of sclerotized or membranous abdominal terga in apterous females of different species of the same genus, is *Lesneia* Badonnel (Elipsocidae) (cf. Badonnel, 1981). In this African genus one species with membranous abdominal terga exists besides two species with sclerotized abdominal terga (cf. Badonnel, 1931, 1963; Broadhead & Richards, 1982). Also in *Lesneia* the sclerotized dorsal shield of the abdomen is of normal shape and does not form a capsule-like structure (cf. Badonnel, 1931: fig. 19). In both cases, *Hinduipsocus* and *Lesneia*, the apomorphic sclerotization of the abdominal terga cannot be considered as a generic character and the definition of further generic divisions within these otherwise very homogeneous series of species seems not to be justified.

As mentioned in the above comparisons with *Hinduipsocus* and *Lesneia*, the abdominal shields observed in these genera are of normal shape and not differentiated as cup-like capsules. The presence of such an abdominal capsule in *Odontopsocus compactus* is unique in the Psocoptera. It represents probably an adaptation to life in humid moss and litter, from where the two known specimens have been extracted. A striking similarity in habitus, due to morphological convergence, can be observed in the females of some litter-dwelling Troctopsocidae belonging to the Oriental genus *Coleotroctellus* Lienhard (cf. Lienhard & Mockford, 1997: fig. 10). In this genus, the capsule is not formed by the sclerotized abdominal terga but by the strongly modified, elytriform forewings. The function of both structures may be the same, but no detailed biological observations on these interesting litter-dwelling psocids have been made up to now. As indicated above (see "Remark") the males of the new epipsocid species are probably fully winged, with normally shaped forewings, as are the males of *Coleotroctellus* (cf. Lienhard & Mockford, 1997). In these cases the mobility of the males represents apparently a more important evolutionary advantage than it could be offered by an efficient abdominal protection in both sexes.

Elytriform forewings with more or less modified venation but less sclerotized membrane have been observed in two other hemiedaphic species of Troctopsocidae: *Protroctopsocus enigmaticus* Mockford and *Chelyopsocus garganicus* Lienhard. In

P. enigmaticus normally winged females are also known, but they are much rarer than the brachypterous females with elytriform forewings (cf. Mockford, 1967: 132), all known males have elytriform forewings (cf. Garcia Aldrete, 1982a: fig. 2). No wing polymorphism has been observed in *Ch. garganicus* (cf. Lienhard, 1998: fig. 43, pl.9g), the male of this species is not known.

Within Psocoptera, coleopterous-like habitus due to elytriform forewings is also known in Sphaeropsocidae and in an isolated case of Psocidae. It may be interpreted as an adaptation to litter-dwelling in the hemiedaphic family Sphaeropsocidae, e. g. *Sphaeropsocopsis recens* (Hickman), found in dry grass tussocks in Tasmania (Hickman, 1934: fig. 4A) and in *Eucalyptus* litter in South Australia (cf. Smithers, 1984). Unfortunately nothing is known on the biology of the only genus of Psocidae where heavily sclerotized elytriform forewings have been observed: *Elytropsocus* Smithers & Thornton, with only one species known, *E. coleoptratus* Smithers & Thornton, from New Guinea (cf. Smithers & Thornton, 1981: fig. 80).

Lachesilla hirsuta sp. n. Fig. 3

MATERIAL

Holotype ♀ (MHNG, slide no 7447 and alcohol). THAILAND: Chiang Mai Province: Doi Suthep (Doi Suthep-Pui National Park), 670 m, evergreen gallery forest, 15.II.1996, leg. P. Schwendinger.

Paratypes. 2♀ (MHNG). THAILAND: Chiang Mai Province: Doi Suthep, near Monthathan Waterfall, 650 m, mixed deciduous forest, pitfall trap, 10.I.-6.II.1997 (1♀, lacking abdomen), 6.II.-26.II.1997 (1♀, lacking left forewing), leg. P. Schwendinger.

DIAGNOSIS

Head and mesonotum densely pilose, about 10 particularly long hairs on vertex (fig. 3h). Veins of forewing (except *pcu*) with one row of relatively long hairs (sometimes two rows on *an*), pilosity denser and longer in basal half of the wing than in apical half; forewing with a characteristic colour pattern (fig. 3a). Female gonapophyses (fig. 3g): two pairs of valvulae present, v2 glabrous, v3 pilose. 9th sternum with characteristic sclerotization around spermapore (fig. 3g).

DESCRIPTION (♀)

Coloration. Head light to medium brown with some small dark patches, postclypeus with brown longitudinal stripes, compound eyes black, antennae, thorax and terminalia brown, legs light brown, abdomen yellowish with some red-brown hypodermal pigment. Forewing with a large brown patch in subcentral position, apical half clear (fig. 3a), hindwing clear (fig. 3b).

Morphology. Head (fig. 3h) and mesonotum densely pilose, with some particularly long dorsal hairs, about 10 of them on vertex, the longest of them about 1.5x as long as the eye diameter. Compound eyes relatively small (IO/D = 2.6), ocelli well developed. Antennae pilose, longest setae in apical half of the antenna more than twice the length of the corresponding flagellomeres. Lacinial tip as in fig. 3f. Pretarsal claw with a preapical denticle, apex of pulvillus slightly expanded (fig. 3i). Pearman's organ on hind coxa well developed. Forewing (fig. 3a) with one row of relatively long

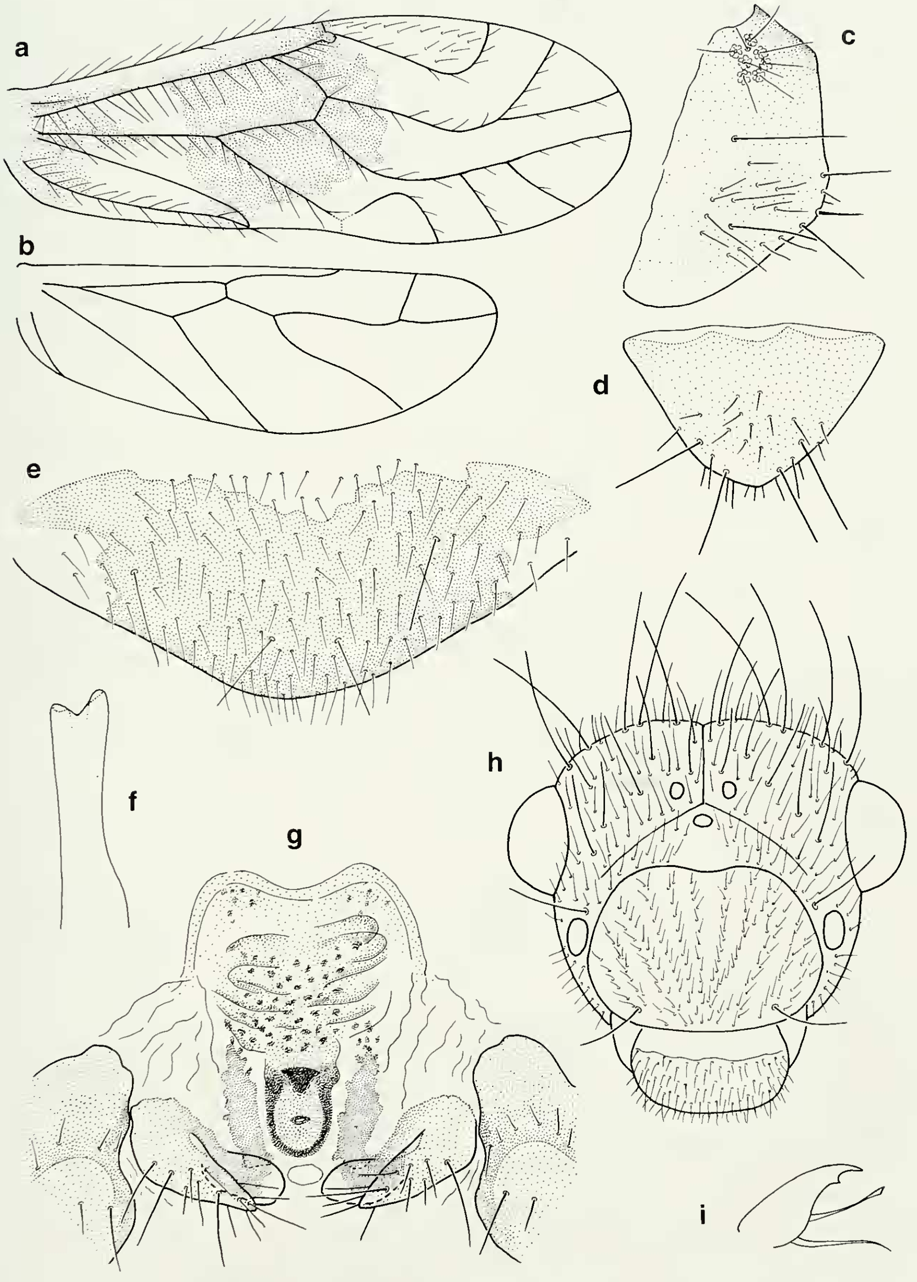

FIG. 3

Lachesilla hirsuta sp. n., female: **a**, forewing; **b**, hindwing; **c**, left paraproct; **d**, epiproct; **e**, subgenital plate; **f**, lacinial tip; **g**, gonapophyses and 9th sternum with spermapore; **h**, head, frontal view; **i**, pretarsal claw.

hairs on veins, sometimes two rows on *an*, *pcu* bare, pilosity particularly dense and long in basal half of wing, wing margin pilose between anterior wing base and pterostigma, otherwise bare, some hairs also on pterostigmal membrane. In forewing *rs* and *m* joined by a relatively long crossvein, *m* usually 3-branched (in left forewing of holotype only 2-branched). Hindwing glabrous, *rs* and *m* basally fused for a distance (fig. 3b).

Epiproct and paraprocts simple (fig. 3c, d), the latter bearing some trichobothria, lacking field of short stout setae along median margin in ventral half. Subgenital plate rounded posteriorly (fig. 3e). Gonapophyses (fig. 3g): two pairs of valvulae present, v2 smaller than v3, glabrous, v3 tapering to its apex, bearing about a dozen setae. 9th sternum with characteristic sclerotization around spermapore (fig. 3g).

Measurements (♀ holotype). BL = 2.0 mm; FW = 1.8 mm; A = 870 µm; F = 420 µm; T = 710 µm; t1 = 198 µm; t2 = 100 µm.

Remark. The male of this species is not yet known, but the presence of sperm in the spermatheca of the dissected holotype female gives evidence of the bisexuality of the species.

DISCUSSION

According to the generic diagnosis given by Garcia Aldrete (1974) and Mockford (1993) the new species belongs undoubtedly to the genus *Lachesilla*, if we leave the pilosity characters out of account. In *Lachesilla* the pilosity on head and mesonotum is well developed but much shorter and less dense than in the new species, without particularly long hairs (cf. for example, Garcia Aldrete, 1982b: fig. 21, 1988: fig. 2). Concerning wing pilosity in *Lachesilla*, Garcia Aldrete (1974: p. 8) writes: forewings "bearing minute hairs along veins and in the pterostigma; wing hairs generally not visible below 150x; wing margins bare". Therefore the general habitus of a *Lachesilla* species is that of a normally pilose psocid with practically bare wings, while *L. hirsuta* sp. n. remembers the habitus of a pseudocaeciliid, characterized by extensive pilosity on head, mesonotum and wings. Even in the few known *Lachesilla* species where forewing pilosity is slightly more developed, the hairs are always much shorter than in *L. hirsuta* (e. g. *L. palmicola*, cf. Garcia Aldrete, 1981: fig 3, or *L. marginata*, cf. New & Thornton, 1975: fig. 69).

In some other genera of Lachesillidae a more extensive pilosity of forewing veins, margin and sometimes membrane has been observed, e. g. *Nadleria* Badonnel & Garcia Aldrete (cf. Mockford, 1985: figs 7, 8) or *Tricholachesilla* Mockford & Sullivan (cf. Mockford & Sullivan, 1986: fig. 135). As in *L. hirsuta*, in these taxa the pilosity generally becomes sparser towards the apex of the wing. But based on general and genital morphology the new species has to be placed in *Lachesilla*, in spite of its unusual habitus. Due to the absence of males, it is difficult to place it in one of the species groups defined within *Lachesilla*. Probably *L. hirsuta* belongs to the *pedicularia* group as diagnosed by Garcia Aldrete (1974) and Mockford (1993). Usually the females of this species group have only one pair of gonapophyses (v3), but Garcia Aldrete (1974: p. 21 and figs 193, 194) mentions the presence of two pairs in some undescribed species (from Central Africa, Uganda, cf. Garcia Aldrete, *in litt.*).

Contrary to the preceding case of *Odontopsocus compactus*, we are not able to interprete the strongly developed pilosity observed in *Lachesilla hirsuta* as an adaptation to a particular mode of life. It is even difficult to establish the evolutionary polarity of this character. In the present case it could be considered as an apomorphic reversal after its gradual reduction to very short and sparse pilosity in most of the Lachesillidae. Within the family-group of the Homilopsocidea, to which the Lachesillidae belong, a well developed pilosity has undoubtedly to be considered as the plesiomorphic character state, observed in most members of several families (e. g. Pseudocaeciliidae, Trichopsocidae, Elipsocidae, Philotarsidae). Only future phylogenetic studies will show if, in *L. hirsuta*, we are in front of a symplesiomorphic resemblance to Pseudocaeciliidae, or if we have to interprete the situation as an autapomorphy of an isolated species within the genus *Lachesilla* (character reversal).

Ectopsocus venosus sp. n. Fig. 4

MATERIAL

Holotype ♀ (MHNG, slide no 7452). EAST MALAYSIA: SABAH: Kinabalu National Park, Mt Kinabalu, 1750 m, Liwagu Trail, beating vegetation, 27.IV.1987, leg. D. Burckhardt & I. Löbl.

DIAGNOSIS

Forewing with *rs* 5-branched and *m* 6-7-branched (fig. 4a, c).

DESCRIPTION (♀)

Coloration. Head and thorax yellowish brown, compound eyes black, antennae and legs light brown, abdomen yellowish (including terminalia), preclunial segments indistinctly annulated with some red-brown hypodermal pigment. Forewing (fig. 4a) slightly tawny, especially in basal and central cells; the following veins with cloudy brown borders: *sc* at base of pterostigma, connection point of *rs* and *m*, distal part of *r*1, branches of *rs* and *m* and distal part of *cu*; insertion points of hairs on veins surrounded by a cloudy brown spot. Hindwing clear (fig. 4b).

Morphology. Compound eyes relatively small (IO/D = 2.5), three ocelli present, but rather weakly developed. Lacinial tip as in fig. 4g. Pilosity of head, antennae and mesonotum well developed, typical for the family. Pretarsal claw with a broad membranous pulvillus, lacking preapical denticle, typical for the family. Pearman's organ on hind coxa weakly developed, only coxal rasp visible. Forewing (fig. 4a,c) with well visible pilosity on veins and margin, *pcu* bare; *rs* and *m* joined by a very short crossvein; *rs* 5-branched in both forewings of the holotype, in the right forewing all branches arising from one point (fig. 4a), in the left forewing (fig. 4c) two of them slightly stalked and arising basally from the first branch, the latter with an additional spur-vein near this bifurcation; *m* 6-branched in the right forewing (fig. 4a), 7-branched in the left forewing (fig. 4c). Venation normal in basal half of both forewings. Hindwing bare, with normal venation, *rs* and *m* joined by a long crossvein (fig. 4b).

Epiproct simple, with some long stout setae; paraprocts with 8 trichobothria, a median row of 5 long stout setae, a similar seta on hind margin and ventrally to it a

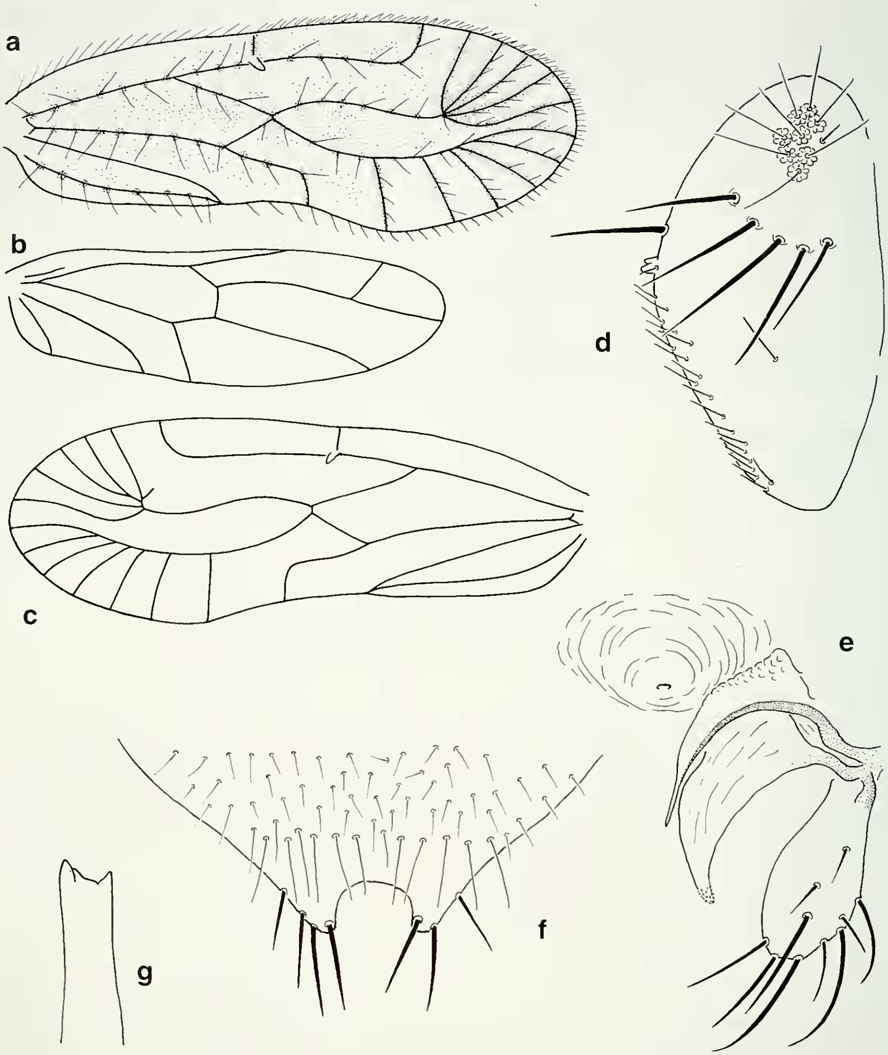

FIG. 4

Ectopsocus venosus sp. n., female: **a**, right forewing; **b**, right hindwing; **c**, left forewing (pilosity and pigmentation not shown); **d**, right paraproct; **e**, gonapophyses and spermapore; **f**, subgenital plate; **g**, lacinial tip.

marginal tubercle, simple on the left paraproct, bifid on the right one (fig. 4d), ventral half of paraprocts with a series of short marginal hairs. Subgenital plate (fig. 4f) apically bilobed, the relatively short lobes separated medially by a semicircular indentation, each lobe with 3-4 stout external and apical setae. Gonapophyses (fig. 4e): three pairs of valvulae present, v1 and v2 apically tapering, glabrous, v3 rounded, with some long setae on apical half. 9th sternum membranous, no sclerotization around spermapore (fig. 4e).

Measurements (♀ holotype). BL = 1.8 mm; FW = 2.1 mm; A = 1.7 mm; F = 480 µm; T = 720 µm; t1 = 235 µm; t2 = 100 µm.

Remark. The male of this species is not known.

DISCUSSION

In the forewing of Psocoptera and in particular of Ectopsocidae the veins *rs* and *m* are usually 2-branched and 3-branched respectively (cf. fig. 3a; in the following called standard venation). In a few cases this number of branches can be reduced (e. g. in the fully winged genus *Ypsiloneura* Pearman, family Caeciliusidae, cf. Pearman, 1932: fig. 1 or Badonnel, 1955: fig. 341), sometimes combined with a reduction of wing length (brachypterous forms of several genera). Multiplication of *rs* and *m* branches has hitherto been observed in some species of the families Epipsocidae, Ptiloneuridae, Amphipsocidae and Calopsocidae, belonging to three different family-groups (cf. figures in Smithers, 1990). In these families it is often not possible to consider the undoubtedly apomorphic multiplication of veins as a generic character, as it has been shown by Mockford (1998) and Casasola Gonzalez (2001) for the genus *Goja* Navas (Epipsocidae), which contains both, species with multiple veins *rs* and *m*, and species with standard venation. In many species of the above mentioned families, showing multiple branching of *rs* and *m*, some intraspecific variability and often some slight intraindividual dissymmetries can be observed (cf. Thornton & Smithers, 1984; Casasola Gonzalez, 2001). But never a similar case of multiple branching merely due to a teratological deformity has been described in a psocid genus with standard venation. In psocids, teratological aberrations of forewing venation are usually characterized by some omitted branches or one extra branch of *rs*, *m* or *cu* or some added crossveins, and they are usually strongly dissymmetric (cf. Clark, 1979). In view of these observations, we exclude here the eventuality of a teratological deformity for the new ectopsocid described above. Based on characters of general and genital morphology this species belongs to *Ectopsocus*, as diagnosed by Thornton & Wong (1968) and Mockford (1993). Due to the absence of males, the species cannot be placed in one of the species goups defined by Thornton & Wong (1968) for this genus.

There is no evident functional interpretation of the particular forewing morphology of *E. venosus*. Multiplication of veins in the apical part of the wing could result in an increase of mechanical stability. Might there be an evolutionary advantage of "wire-netting" the forewing apex, even in such a small species (wing length 2.1 mm) ? – In this context it is interesting to see that all other psocids with multiple veins are much larger, with forewings usually about twice as long as in *E. venosus*, up to more than 5 mm in *Goja*, for example (Casasola Gonzalez, 2001).

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